The IST-05 Reference Model in Evaluation and Design

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INTRODUCTION

A "visualisation system" is a system for presenting, probably interactively, some part of a dataspace, in such a way that a user with some purpose in mind can visualise the import of the data for that purpose. Visualisation is something that happens in the head of a human, and may be evoked not only by graphical presentations, but also by text, or even by non-visual presentations such as touch and sound.

Visualisation is taken to be one of two parallel routes to understanding, the other being analysis. Analysis works primarily by applying reasoning in the form of logic or mathematics to identifiable discrete entities, whereas visualisation often involves the perception of patterns involving the relationships among many items that may not even be individually identifiable. In many situations understanding is best achieved by the mutual support of visualisation and analysis, visualisation providing a context within which analysis provides precision.

The IST-05 Reference model describes visualisation systems in a way that is both general and precise. Because of its generality, it can describe and guide the evaluation of any visualisation system, and as a consequence of its precision, it can be used to guide the system's design and evolutionary improvement.

The Model is based around a hierarchy of feedback loops. In an outer loop, the human interacts with the dataspace, selecting and manipulating the data and the way the data is viewed, until its import for the human's purpose can be effectively understood. Of course, the human cannot do this by direct observation if the dataspace is bits and bytes in a computer memory.

To avoid the need for telepathy in manipulating and understanding the data, the IST-05 Reference Model incorporates a processing loop inside the main outer loop. In this inner loop, the human's visualising processes interact with "Engines" in the computer. Engines are defined as processes that select and organize the data, under the control of the human user. Engines also prepare the data for display by the physical output devices. Engines are therefore tools that convert the human's physical manipulation of the input devices into operations on the data in the dataspace, and convert segments of the data into forms that the output devices can present to the human. These input and output devices connect to form an innermost major loop that is concerned only with the human's physical interactions with the display systems.

In the IST-05 Reference Model, then, the outer loop links human understanding with the dataspace, a middle loop links human visualisation with the Engines in the computer, and at the innermost level, the I/O devices allow these loops to take physical form.

EVALUATION

The reference model describes only one inner and one outer loop, but each of these can be analyzed further, both as a skein of parallel loops and as a structure of hierarchic support loops. An individual

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elementary loop is defined by a purpose that relates to a perception of some aspect of the dataspace. If the current perception satisfies the purpose, then nothing needs to be done, but ordinarily this is not the case, and the human needs to act in some way to alter what is perceived. This defines a simple control loop, which is at the core of the evaluation procedure.

A complete evaluation would consist of identifying every purpose the user might have, from the high-level purpose of understanding, say, the intentions of a battle adversary to the low-level purpose of striking the "k" key on a keyboard. Of course, few, if any, evaluations would be so complete. But the evaluation of each loop defined by a purpose contributes to the evaluation of the system as a whole.

A loop is defined by a purpose, so the first stage in evaluating a loop is to determine its purpose. The second question is to determine what information needs to be available to inform the human's perception, if that purpose is to be achieved. For example, if the purpose is to determine whether a computer network is under distributed attack, the purpose cannot be achieved unless the user can see that certain message packets are coming from different hosts. A display system that provided information about the packets only as a homogenous stream would not serve that purpose.

This second question also has a bearing on user training. A naïve user may need to get information from the system that an expert user would already have available in memory. In evaluating a system, the evaluator must be aware of the possible partitioning of the necessary information into that which is obtained or obtainable from the displays and that which must already be known to the user.

The third question to be asked in an evaluation is what the human needs to do if the current purpose is not served by the currently available information from which the perception is derived. Can the user influence the dataspace so as to get the desired information from it? To continue the previous example, could the user act so that the source hosts of message packets became available to the display? Training also must be considered here, as a naive user may not be aware of means of action that are actually available.

Two more questions complete the evaluation of a single loop. They are what impediments might there be to observing what needs to be observed, and what impediments might there be to acting effectively to generate the desired observations. Impediments can be both internal and external.

An internal impediment to observation might be inadequate display resolution or, at a higher level, lack of an Engine that appropriately interprets the data about packet sources even though those data might exist in the dataspace. In other words, an internal impediment to observation is something on the information pathway between the dataspace and the human, whereas an external impediment to observation might be glare on the screen, or at a higher level, interference from other information being simultaneously displayed and demanding attention – in other words, interference due to attention-splitting. One may consider an internal impediment to be analogous to a restriction of channel bandwidth, and an external impediment to be analogous to an noise added into the channel.

An internal impediment to action might be the lack of an input device with enough degrees of freedom to effect the desired control, or at a higher level, the lack of an engine with appropriate algorithms for selecting data that would be required to create the information needed for the desired observation. An external impediment to action might be the joggling of the command vehicle in which a system was installed, or at a higher level, the sharing of processor resources among compute-intensive engines, such that acting to generate one observation inhibited the possibility of acting to generate another.

Finally, there is a sixth question that relates not to the operations of the single loop being examined, but to the fact that one simple control loop of the model is actually a skein of parallel loops. This sixth question asks if there is some way that the user can be alerted to conditions in which a purpose not currently being actively pursued might be worth pursuing immediately. Maybe important new data has come in that must

be dealt with, or, in a more passive environment, maybe an engine has identified some pattern in the data that corresponds to something the user has indicated might be "interesting."

The six questions for any loop can be summarized as follows:

1) What is the user trying to achieve at this point?
2) Can the user perceive whether there is progress toward the goal?
3) Is the user able to influence progress toward the goal?
4) What internal or external impediments might there be to perceiving what is necessary?
5) What internal or external impediments might affect the user's ability to act appropriately?
6) What provision is there to alert the user that something else needs attention?

DESIGN

Design is very much the complement of evaluation. The same six questions for each loop can guide a design. First one asks what the probable user will be wanting to achieve by using the system under design, and that defines the required information flows in the outer loop (presuming the designer knows the characteristics of the dataspace). Each possible action provides a purpose at the next level, which defines another loop, and so forth untill all the potential observations and actions have been incorporated into interactive loops (interaction may be num,m if the display is to be passive, but usually interactive displays are more informative than passive ones).

Not can design *ab initio* be guided by the IST-05 Reference Model, but also evolutionary improvement can be guided by the specific deficiencies identified in an evaluation. If a purpose defined in question 1 is not well satisfied by the answers to questions 2-5, the nature of the problem should be immediately apparent, and a solution, if not obvious, should at least be conceivable.

An example of an imaginary Marine tasking system based on a 3600-year old fresco was used to illustrate the power of the principles and practices embodied in the apparently simple IST-05 Reference Model. The PowerPoint presentation describes the method and the example.

SYMPOSIA DISCUSSION – PAPER NO: 3

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Discussion deferred to plenary discussion session.

The VisTG Model for Visualisation

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A “visualisation system” is a system for presenting, probably interactively, some part of a dataspace, in such a way that a user with some purpose in mind can visualise the import of the data for that purpose.

Important words in this definition

presenting: *The system organizes the data for the user’s senses, which need not necessarily be visual*

interactively: *The user can influence what the system presents*

some part of: *Not all of the data can be presented at once*

dataspace: *There is a delimited set of data*

purpose: *The user is trying to perform a task for which the system may provide some assistance*

the import of the data: *The user does not want to visualise the data. What the user wants is to see how the data affect the purpose.*

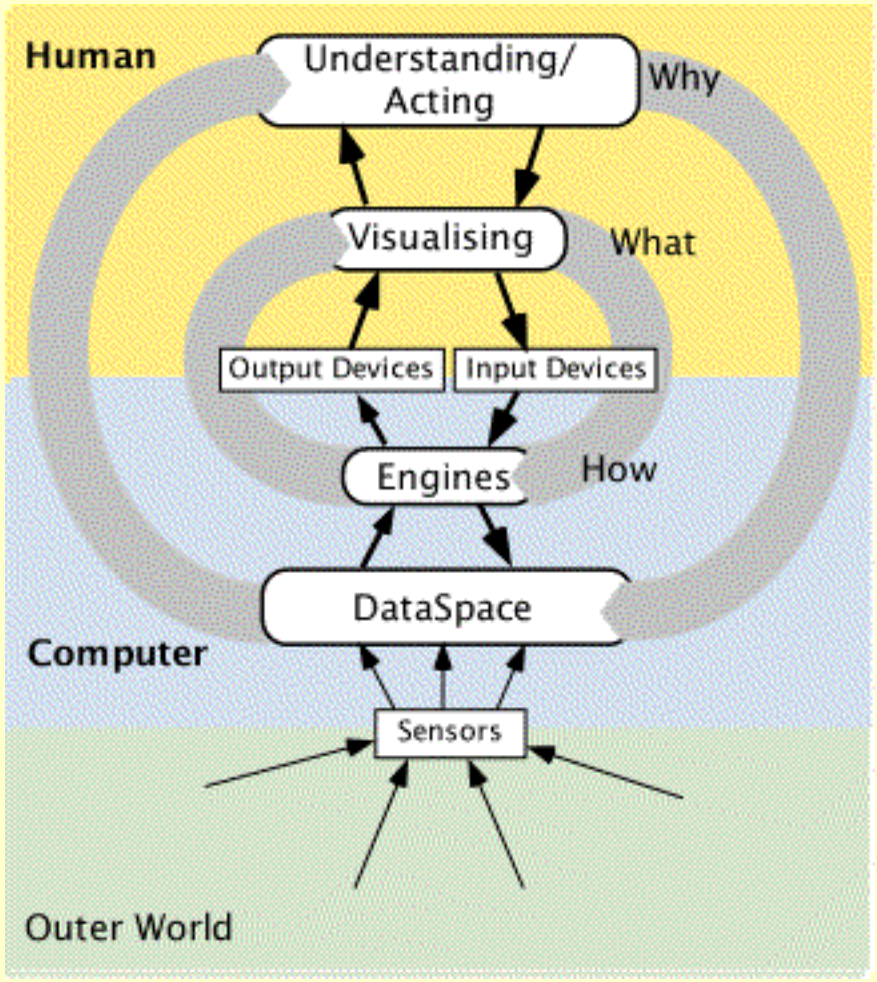
Some Purposes of Evaluation

1. Evaluation for acquisition: *Will the proposed system do the job for which it is intended?*

2. Evaluation for research: *What techniques work better for what tasks?*

3. Evaluation for iterative design: *What aspects of this system work well, and what aspects could be improved?*

The VisTG Reference Model



The VisTG Reference Model has 3 loops, the outer acting through the inner:

(1) The user understanding and acting on the data in the dataspace, which involves...

(2) The user visualising the data provided by and massaged by the engines under the control of the user, using...

(3) The Input-Output devices that interact with the user's sensors and musculature.

But we assume that the user "really" wants to influence the outer world!

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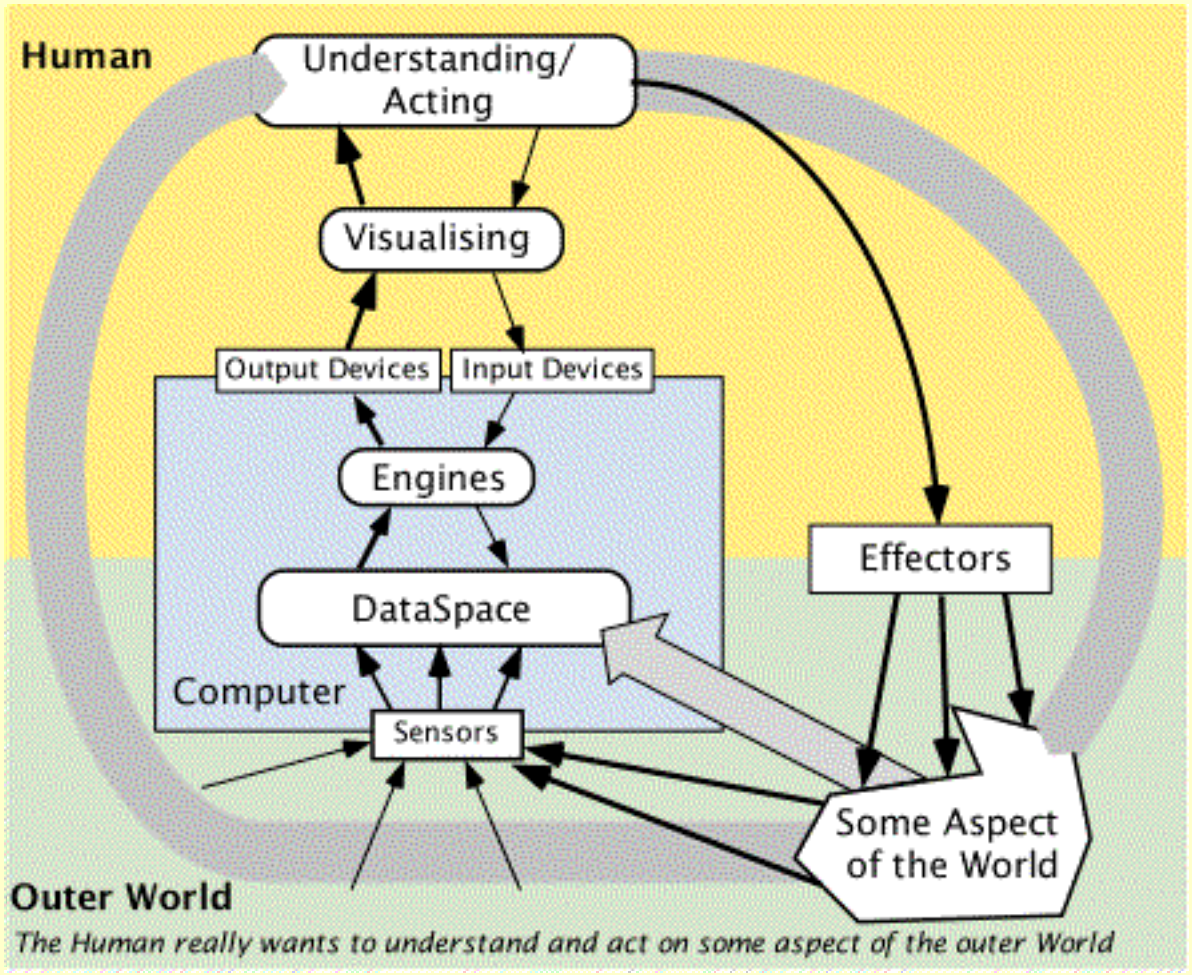
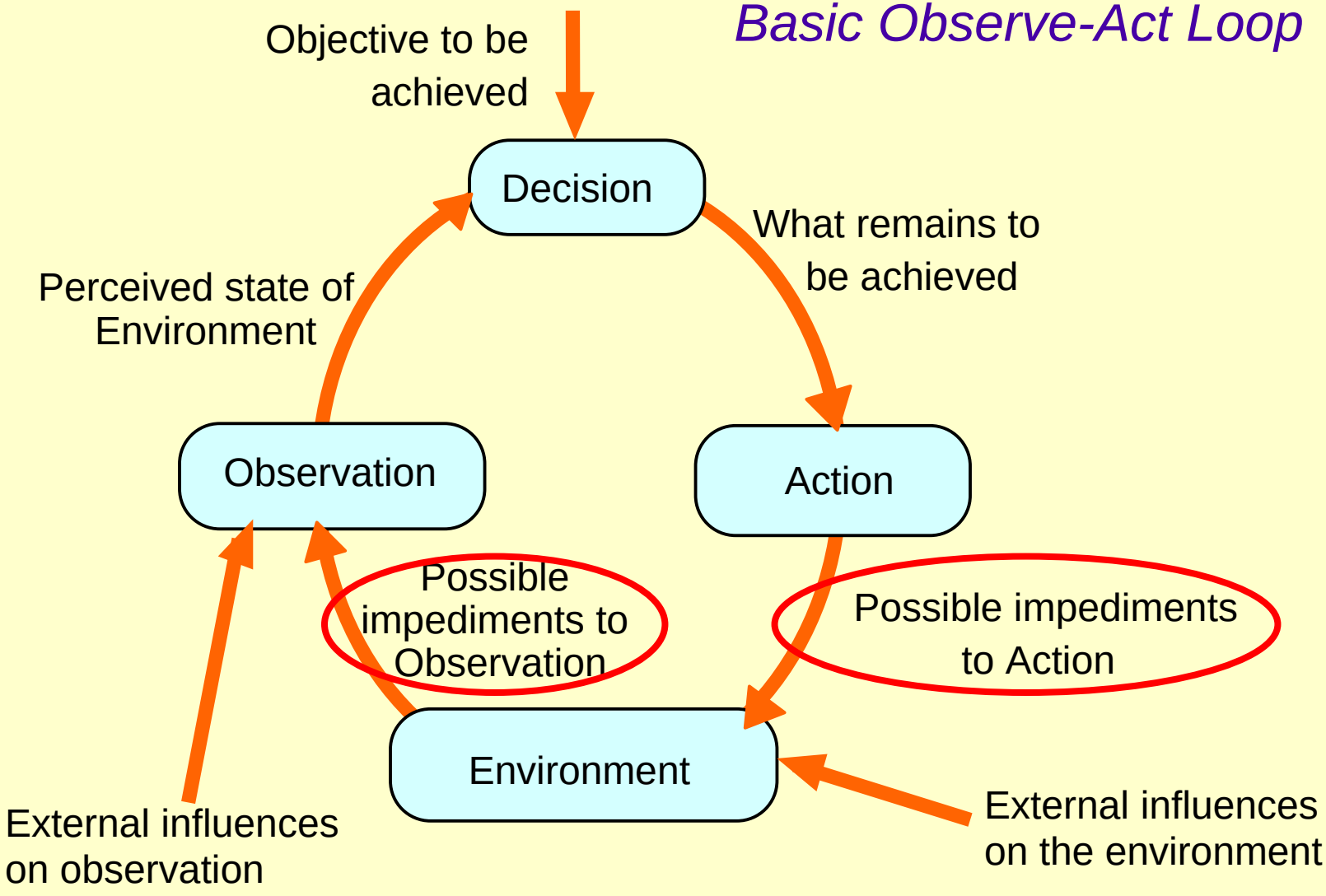
We assume that the user wants to influence the outer world



Basic Observe-Act Loop



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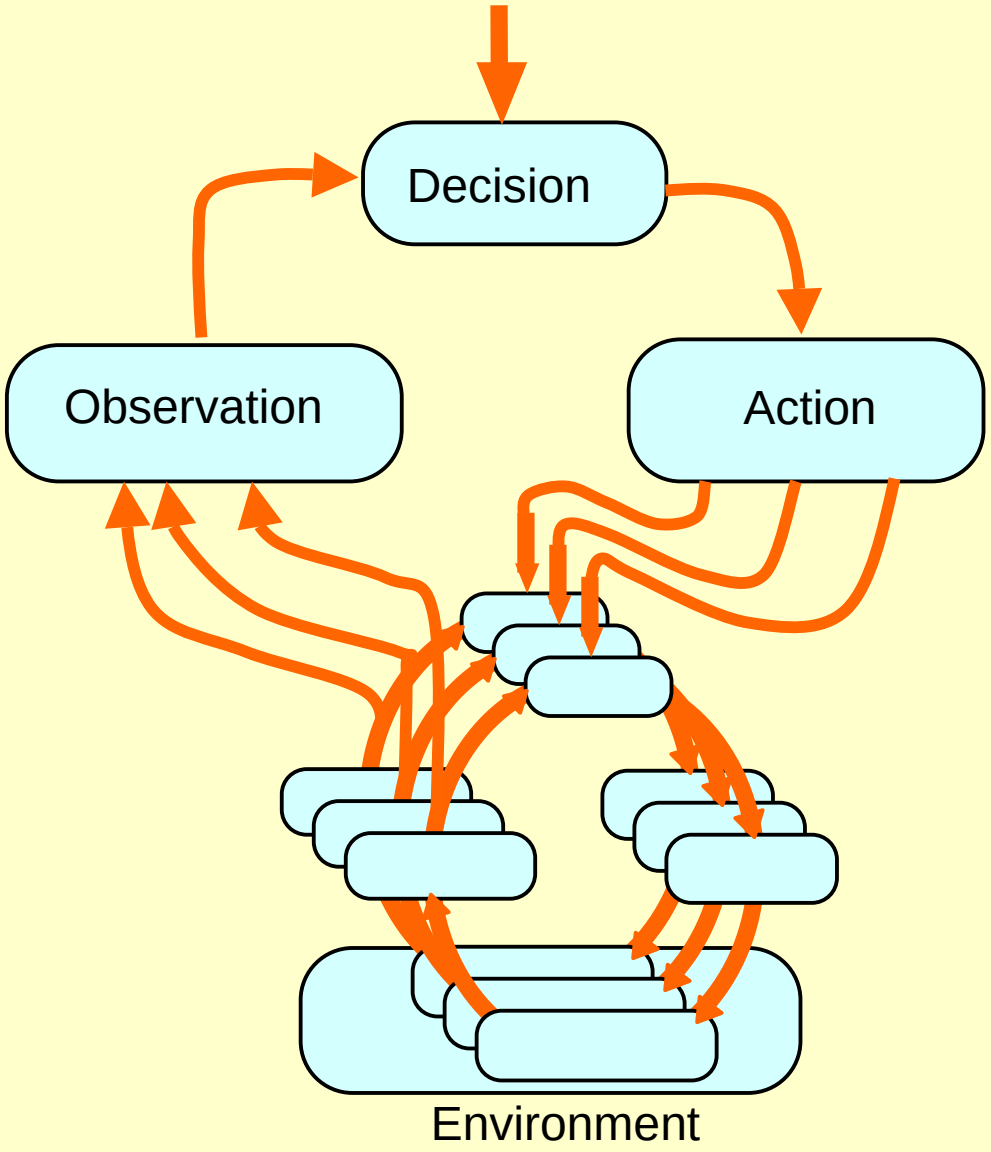
Action Loops are usually multi-level



Each simple loop usually involves multiple lower-level loops of the same kind.

Each high-level perception is usually a function of many lower-level ones, and each high-level action is executed by many lower-level ones.

At every level, an evaluator may ask the six questions described in the next few slides. This diagram suggests 24 questions to be asked, 6 for the outer loop, and 6 for each of the lower-level (inner) loops.

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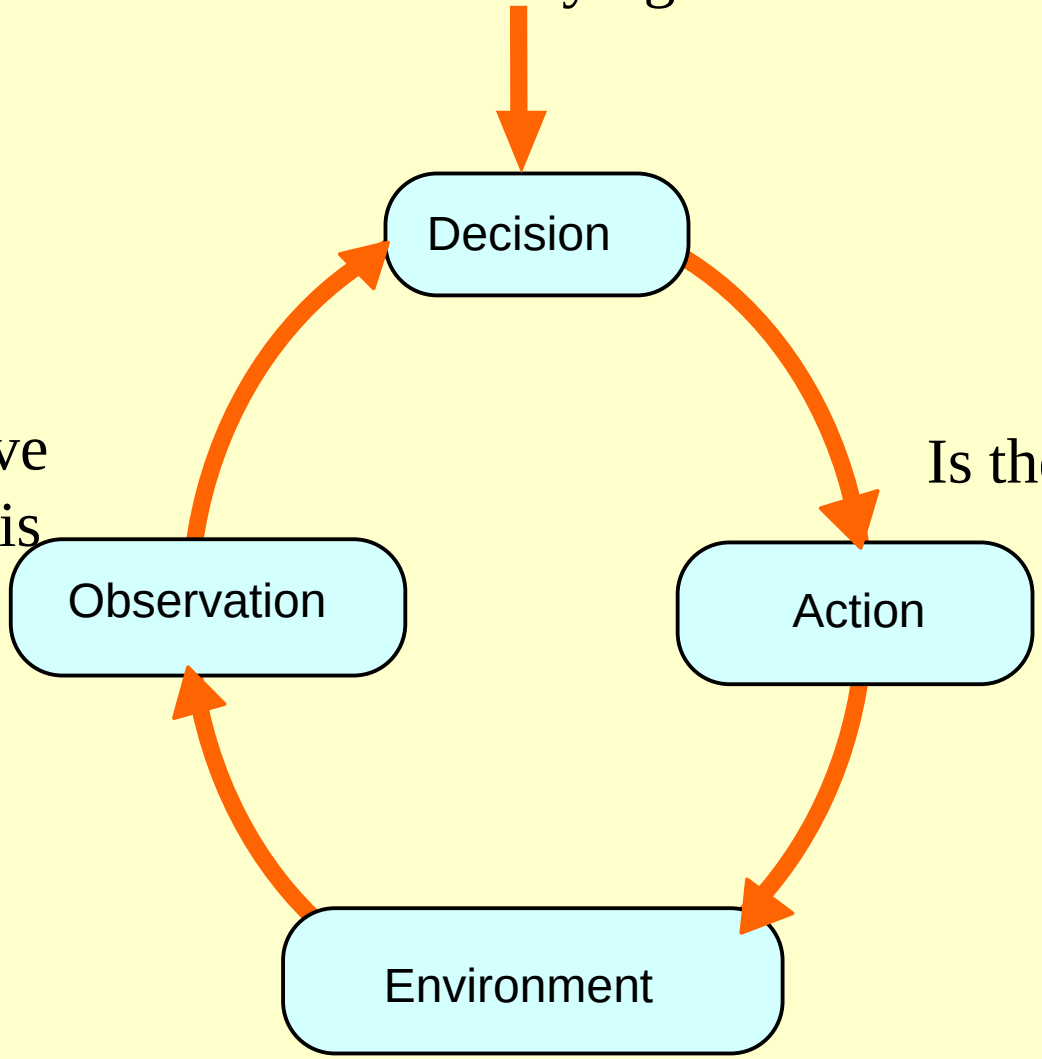
Basic Questions

What is the user trying to achieve?



Can the user perceive whether the engine is tending toward achieving the goal?

Is the user able to influence the element?

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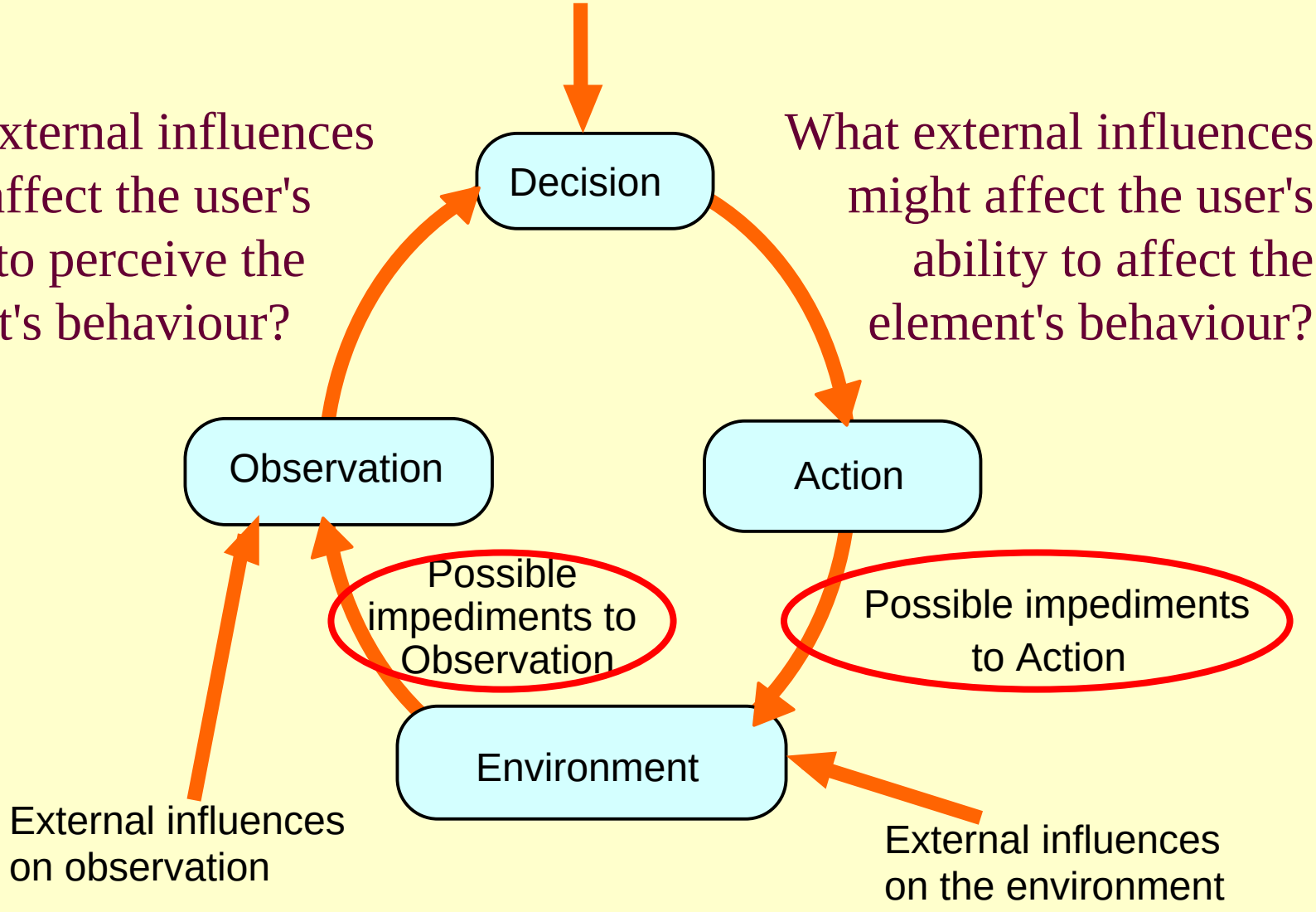
Further Questions

What external influences might affect the user's ability to perceive the element's behaviour?

What external influences might affect the user's ability to affect the element's behaviour?



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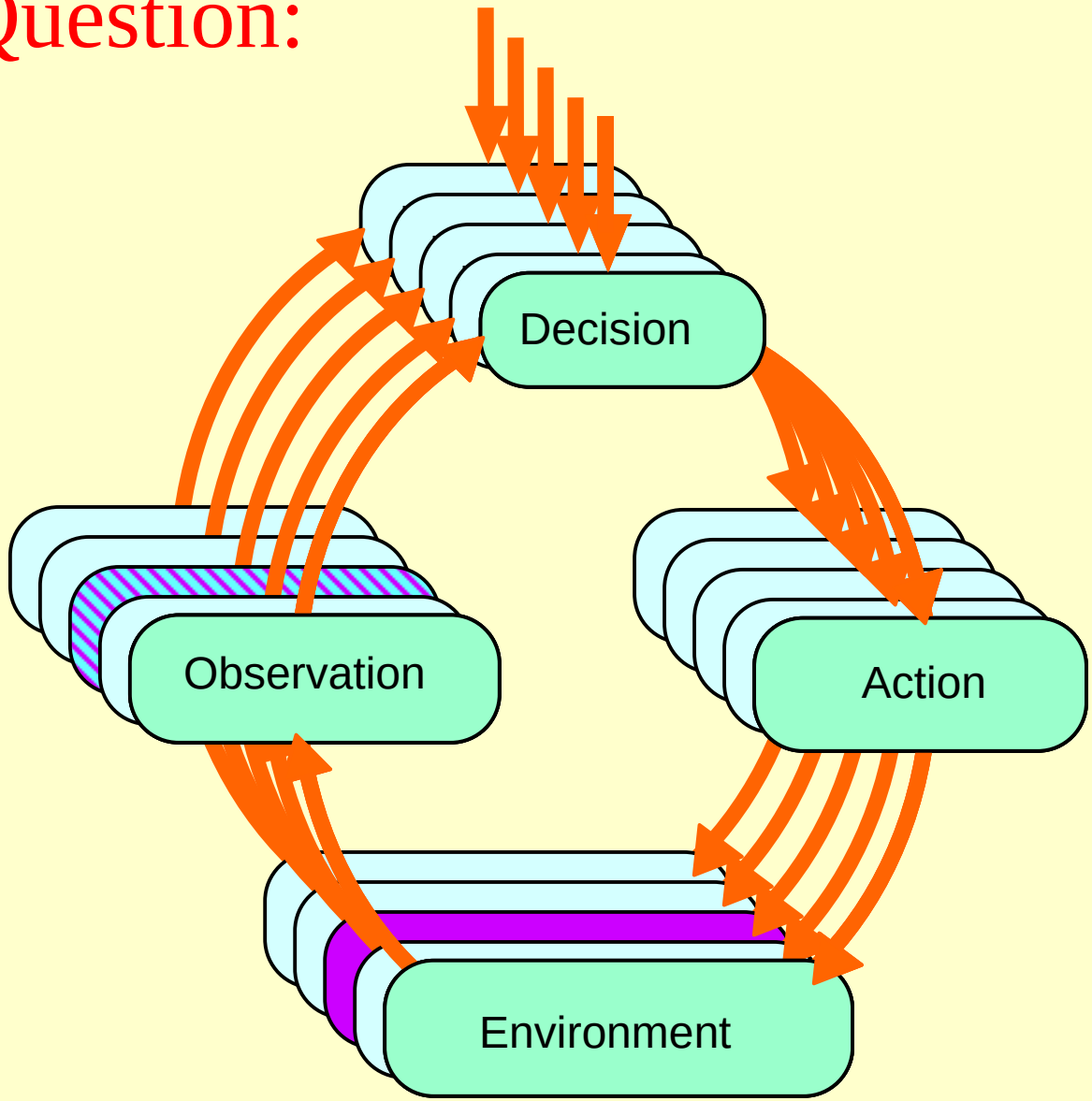
Supplementary Question: Alerting

Of the many elements of the environment to which the user might be attending, is there provision for alerting him or her to the one(s) that might be important at the moment? And of indicating which may be unimportant?



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Six Questions to ask

1. What is the user trying to achieve at this point?

2. Can the user perceive whether there is progress toward achieving the goal?

3. Is the user able to influence the element?

4. What external influences might affect the user's ability to perceive the element's behaviour (and does the user know how)?

5. What external influences might affect the user's ability to affect the element's behaviour (and does the user know how)?

6. Is there provision for alerting the user to any other element(s) that might be important at the moment?

An ancient Fresco

that uses

some “modern” techniques for

aiding cognitively correct

visualisation

In much of this presentation, I will refer to a fresco painted about 3700 years ago, first in terms of the intent of its creator (as I imagine it), and then as the basis for an imaginary interactive visualisation system that I will evaluate using the six questions based on the VisTG Reference Model.

Presentation techniques, old and new

This is a fresco about 3.6m long from Akrotiri (Santorini, Greece) painted at least 3650 years ago, showing a festive fleet travelling from one city to another. I interpret the departure city as being a city that vanished in the 1628 BC explosive eruption of Santorini, and the destination as Knossos in Crete.

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Evaluating the fresco by means of the six questions

1. What is the user trying to achieve?

The painter is trying to allow the user to visualise an entire day's events from one conceptually, but not photographically, accurate image. The fresco is a kind of "briefing slide."

The departure, and after (note the two people at left, for whom the excitement is over). Note the hazy buildings at the right, which suggest that the city is much larger than is shown. Most of the fleet departs from this city, but not the ship at upper right, which I interpret as the lead ship from Akrotiri. If this is Santorini, the view is from the west and the ships head south.

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Evaluating the fresco by means of the six questions

1. What is the user trying to achieve?

Briefing slide (continued)

The voyage of the fleet. Many aspects of the ship images attest to the precision of the painting. Among them, note the “sunflower” emblems on the bowsprits, which seem to be insignia of rank. Two 36-oared ships have one, two 42 and one 46-oared ships have 2, and the 42-oared decorated “flagship” shown at the top has four. On all ships except the flagship, most of the passengers are wearing white. The sailing ship at the right matches almost exactly a picture of a Phoenecian ship of a couple of hundred years later.

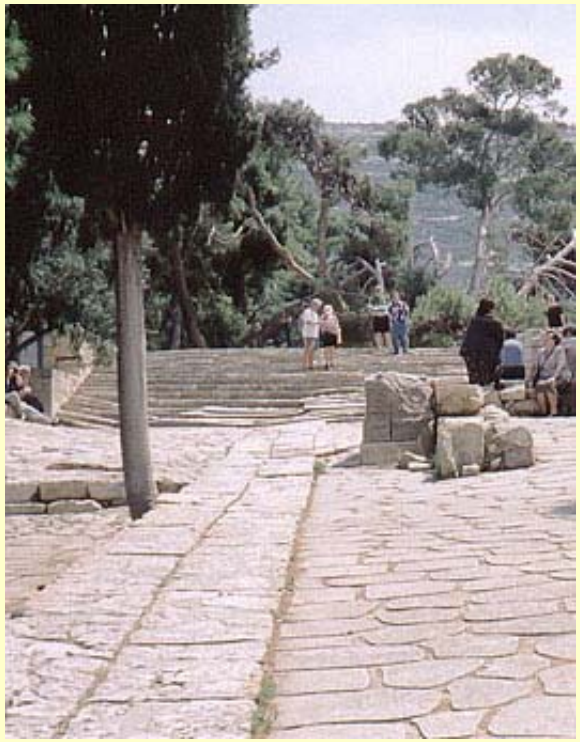
Evaluating the fresco by means of the six questions

1. What is the user trying to achieve?

Briefing slide (continued)

Navigational landmarks. Passing Mallia and its small harbour along the coastline of Crete, the harbour of Amnissos, and the destination steps (the “Theatral Area”) outside the Knossos temple/palace.

Two key places in the fresco as they are now



(Left) The Palace/Temple of Mallia, with Profiti Ilias in the left middle distance. Note the red brick in the foreground. (Above) Knossos: The “Theatral Area” steps outside the Palace/Temple.

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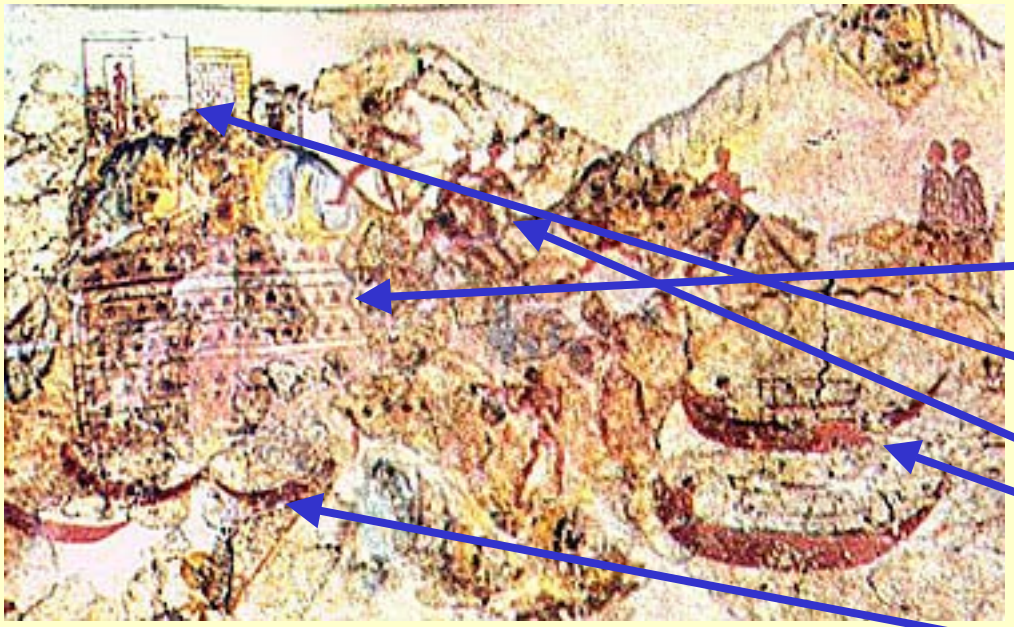
Evaluating the fresco by means of the six questions

2. Can the user perceive whether there is progress toward achieving the goal?

In this case, there is nothing dynamic in the presentation, so the progress is in the viewer's (the user's) head. The dynamics is induced by the presentation technique. "Achieving the goal" means understanding the events in context.



This part of the picture is especially interesting. (1) the geographic context would have told anyone from Thera where this is. (2) The red but transparent building has to be the palace at Mallia, with the Profiti Ilias peak sanctuary on the hill behind, up which excited children run to see the approaching fleet, and from which others run to warn the city. (3) The small (Mallia) and large (Amnissos) harbours complete the stage setting.

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Evaluating the fresco by means of the six questions

1. What is the user trying to achieve?

The painter is trying to allow the user to visualise an entire day's events from one conceptually, but not photographically, accurate image. The fresco is a kind of "briefing slide."

2. Can the user perceive whether there is progress toward achieving the goal?

In this case, there is nothing dynamic in the presentation, so the progress is in the viewer's (the user's) head. The dynamics is induced by the presentation technique. "Achieving the goal" means understanding the events in context.

3. Is the user able to influence the element?

No, but the user can navigate the focus of attention around the dataspace, and must do so, because it is too large to be taken in from a single view.

Evaluating the fresco by means of the six questions (2)

4. What external influences might affect the user's ability to perceive the element's behaviour?

The location of the fresco (high on a wall). The illumination. The size of important detail. The inconsistencies of scale...

5. What external influences might affect the user's ability to affect the element's behaviour?

None, since this is a static image.

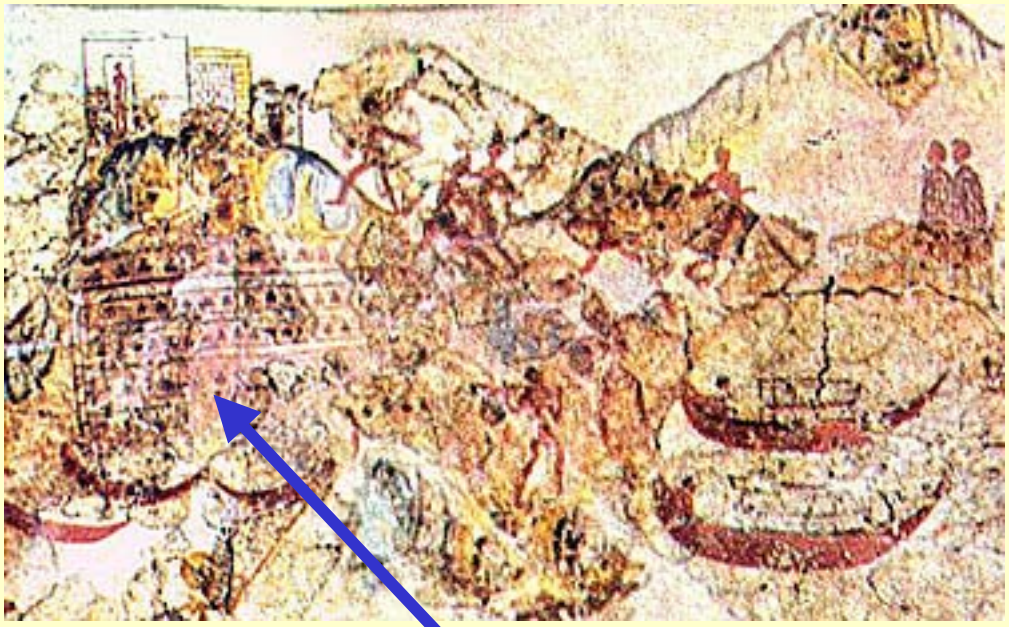
6. Is there provision for alerting the user to any other element(s) that might be important at the moment?

Size and contrast for important elements, translucency for elements that provide context but are not intended as focal points.

Presentation techniques to aid visualisation

Translucency: Indicates the existence of the translucent item to provide context for the focal items, while indicating its unimportance to the concept being illustrated.

The translucent buildings suggest that this is a big city, which probably helped the viewer to identify it.



The big red-brick Mallia palace is translucent, almost evanescent, because it could have been a likely destination, but is in this case only a waypoint for navigational purposes.

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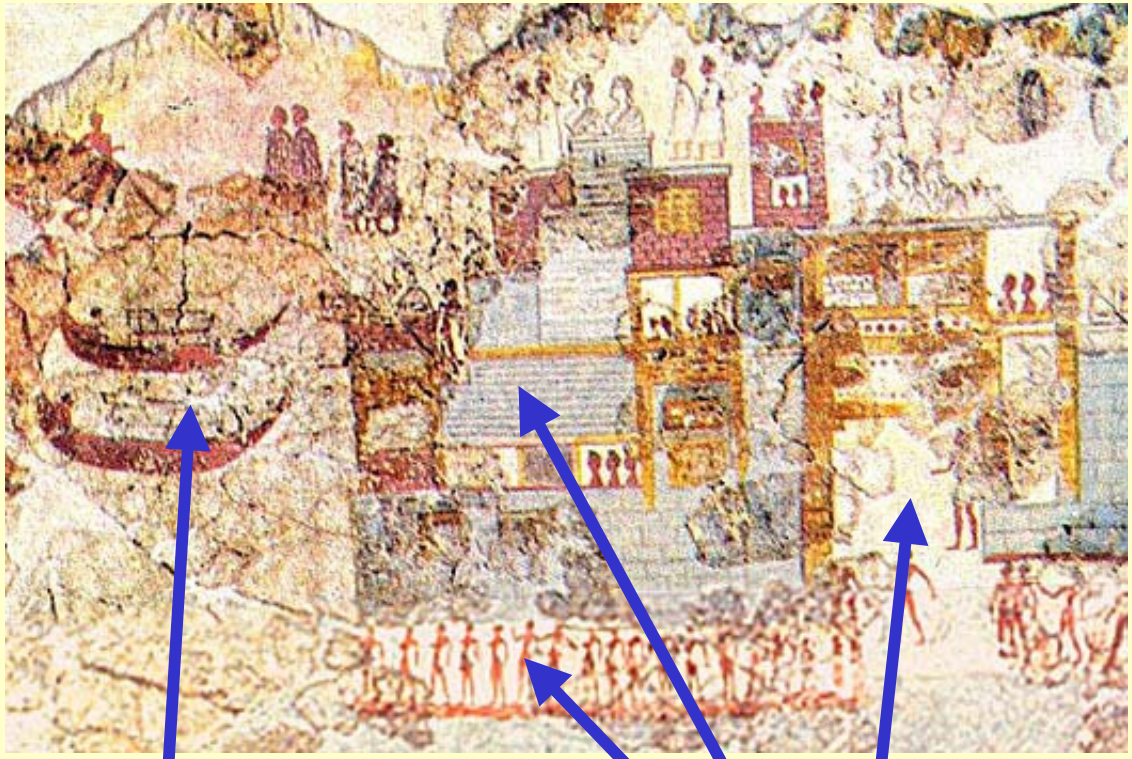
Presentation techniques to aid visualisation

Foregrounding-Backgrounding: If the true relationship of the items is known to the viewer, placing them relatively closer and further can indicate their relative importance to the concept illustrated.



Although the grey steps are not in the foreground of the picture, they are "foregrounded" in the sense that they are shown at all, since the real steps are 5 or 6 km inland and invisible from the sea. Also, they are shown in an impossible position, on top of a window full of onlookers.

Imagining the Fresco

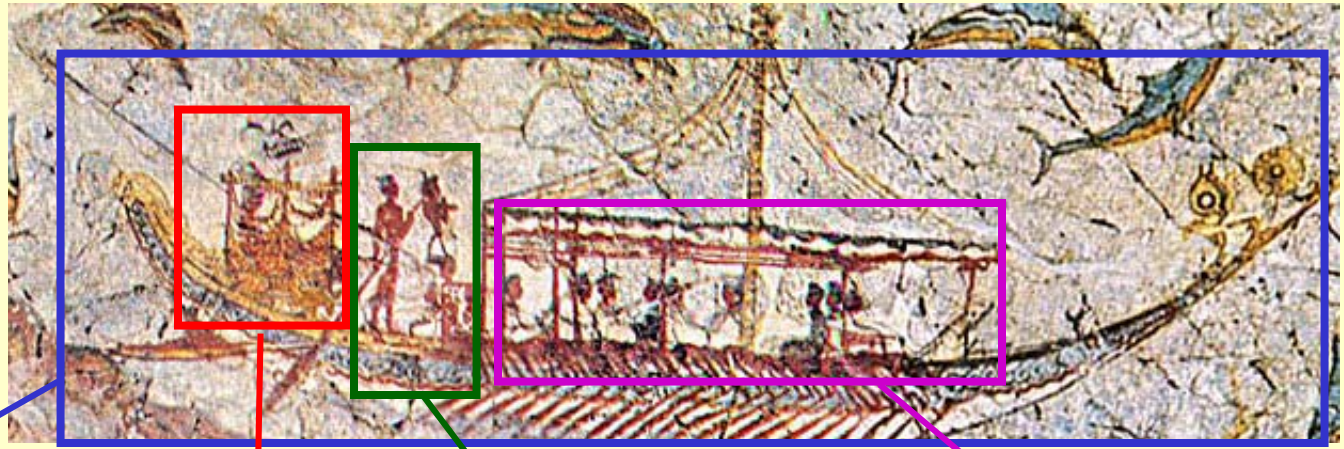
as an interactive interface

for the development and use

of a Marine Tasking Order

The fresco may be a 3650-year old painting, but it can be imagined as an interactive interface for display on normal computer screens or on a full-wall display. In what follows, it is imagined as a full-wall display, and the resulting interface evaluated using the VisTG Reference Model.

Imagining the fresco as an interactive interface for developing a "Marine Tasking Order"



Emplace a defined ship type to add one to the fleet, and locate it according to its origin.

Captain: Click for basic mission statement form, such as:

Ship ID: Akrotiri Leader

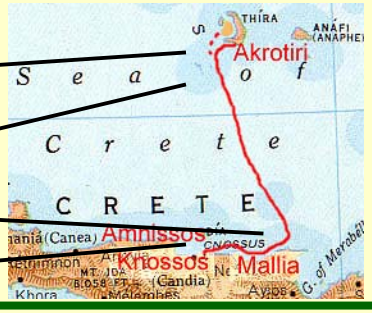
Depart Akrotiri 07:00

Join Main fleet off Pharos 08:30

Off Mallia East 17:00

Arrive Amnissos 20:00

Navigator: Create or show route map:



Loadmaster: Create or view passenger and cargo manifest

Example: developing the mission and details for the lead ship from Akrotiri

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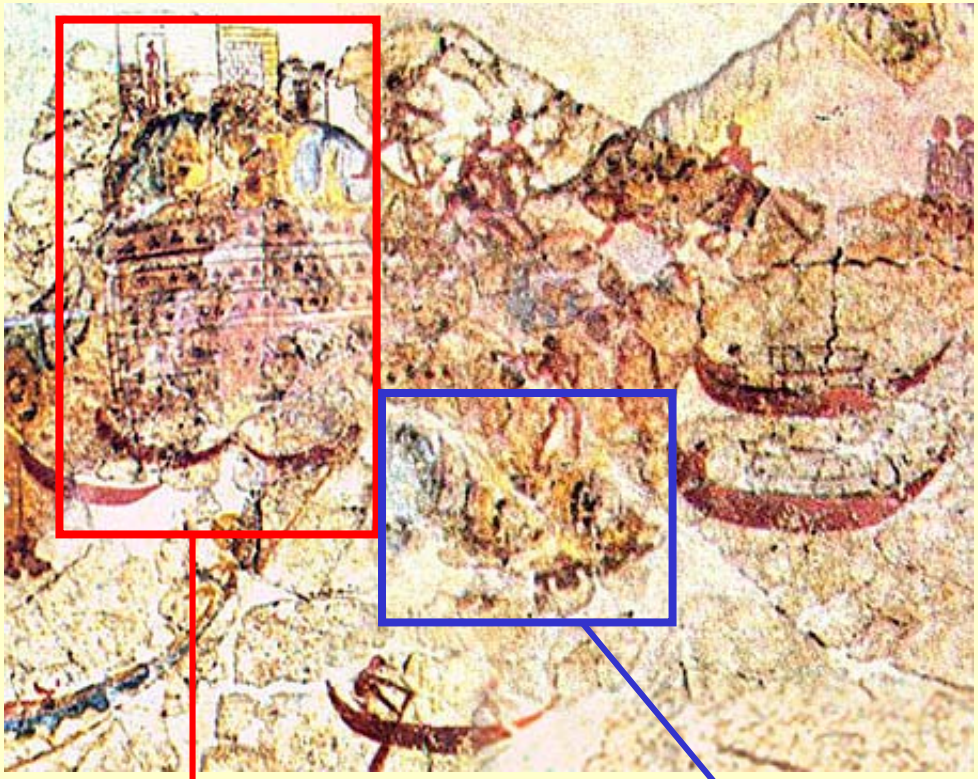
Imagining the fresco as an interactive interface for developing a "Marine Tasking Order"



On arrival, bypass Mallia (shown by the transparency of the landmark building).

Round the headland between Mallia and Amnissos

The depiction of the coastline could serve as a navigational instruction and reminder. To use such a scheme in an interactive system would presuppose the possibility of making synthetic views from digital elevation maps and from photographic imagery, but today's technology makes this possible.

The headland in question is in a 30km stretch of coast, and so a nonlinear representation would be required for effective synthesis.

Example 2: Instructions for the arrival at Amnissos.

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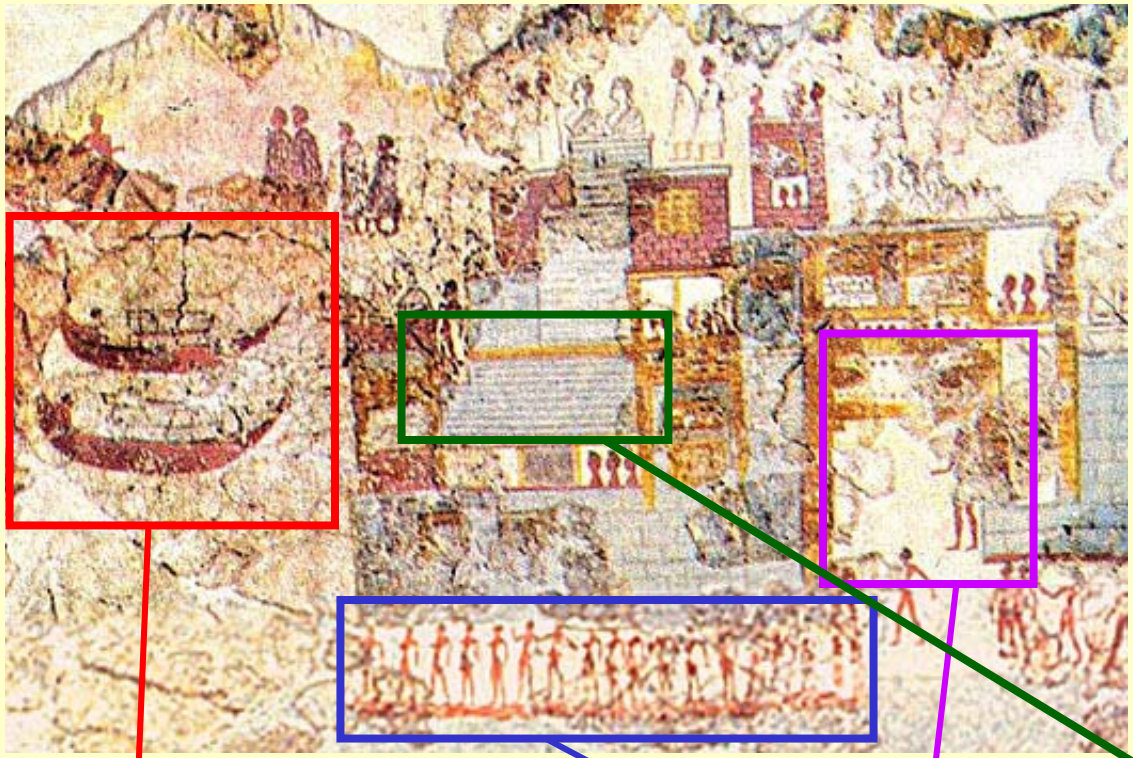
Imagining the fresco as an interactive interface for developing a "Marine Tasking Order"



I assume that the user of this imaginary interface would be familiar with Amnissos and Knossos. The "Theatral Area" steps are 5 or 6 km inland, and would not be visible from the sea. The reason for showing them in the fresco would be that they are cognitively important, presumably being the final destination of the fleet's passengers.

Do not go to the ship basin *(Note the deep set-back from the wharf)*

Arrive at the wharf, where people will be awaiting you.

Proceed up the "Royal Road"

The destination is the "Theatral Area" steps in Knossos.

Example 2b: Final arrival instructions.

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Evaluating the imaginary "Fresco" interface

Q1. What is the user trying to achieve?

This leads to:

Q1a. Who is the user?

A1a: User 1 is the author of the Marine Tasking Order, User 2 is the ship captain receiving the MTO, and User 3…N is any other officer to whom the MTO is relevant

A1.1: (MTO Author) To create an MTO that delivers the fleet and its passengers to Knossos on time.

A1.2: (Ship Captain) To visualise the mission in terms of the intent of the MTO author; to visualise how his ship movements relate to those of the fleet.

A1.3: (Navigator) To visualise the route and the landmarks involved in following it.

A1.4: (Loadmaster) To organize the passenger loading as specified.

The rest of the evaluation will mostly be from the viewpoint of the MTO Author

Evaluating the imaginary "Fresco" interface

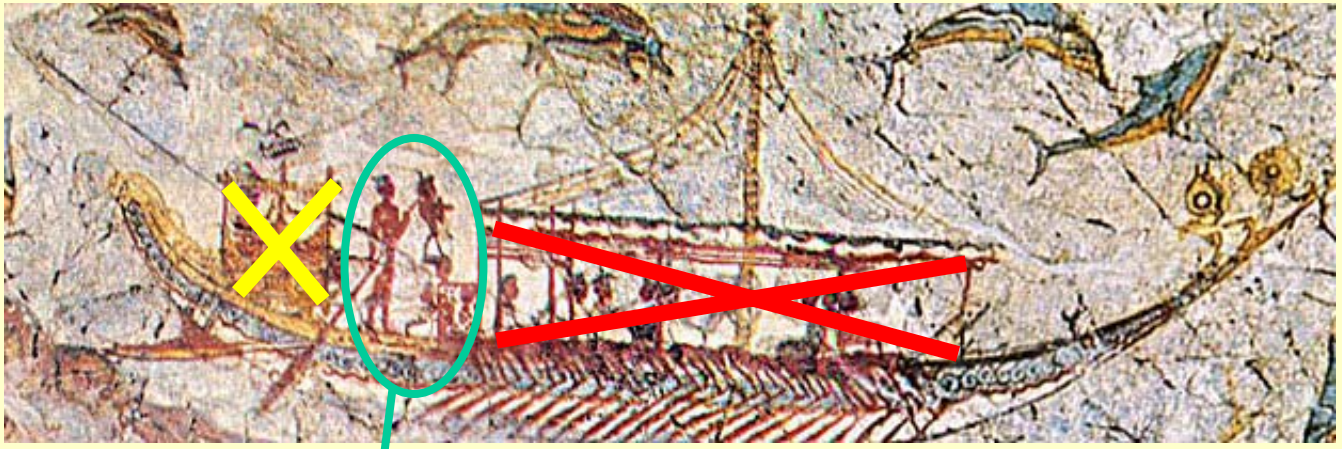
Q2. Can the user *(the MTO Author in this case)* perceive whether there is progress toward achieving the goal?

A2. By scrolling across the display, the MTO Author can determine whether ships have been assigned, whether departure and arrival locations have been described, and whether navigational aids have been represented.

(As stated, so far, the MTO Author cannot immediately see whether the assigned ships have been properly tasked. This leads to an immediate design reconsideration: *How should the MTO Author be made aware that the tasking of some ship has not been completed, or that it conflicts with the tasking for some other ship?)*

Consequent interface redesign: The "Captain's Cabin" on a ship should be displayed in a different way if the Captain's tasking is not formally complete. Similarly for the "Steersman" and the "Passenger Cabin" if the routing and the passenger manifest are not valid. Let us assume that an incomplete component is signalled by an overlaid yellow "X" and an invalid or missing one by a red "X". There are many other possibilities, but some such indicator is needed.

Evaluating the imaginary "Fresco" interface



A partially tasked ship. The Captain's sailing orders are incomplete and the passenger manifest is missing, but the sailing route has been defined.

The sailing route display could include both map and navigational text, for example:

- Depart Akrotiri westward along Thera coast
- On meeting fleet, turn south.
- When Mt Diktas visible, steer toward it.
- On reaching coast, follow landmarks as shown on main display.

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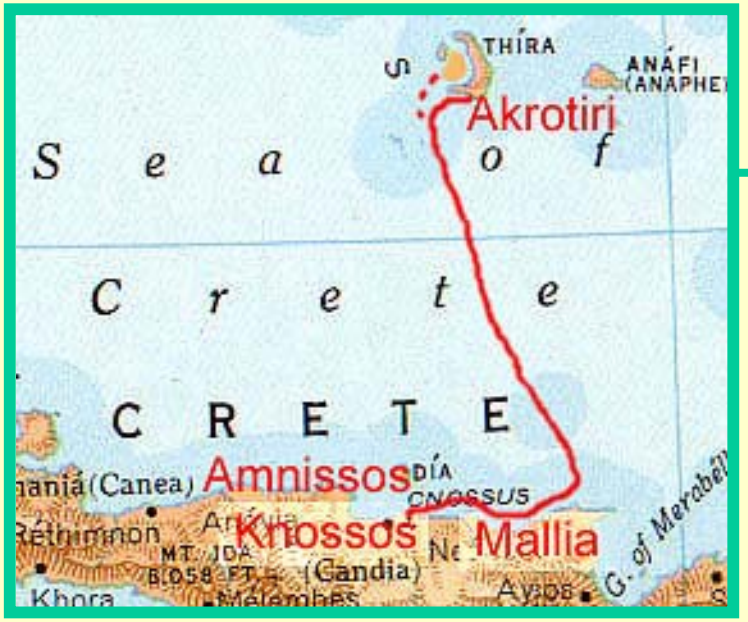
Evaluating the imaginary "Fresco" interface

A side-issue: Why this unnecessarily long route?



Depart Akrotiri westward along Thera coast

On meeting fleet, turn south.

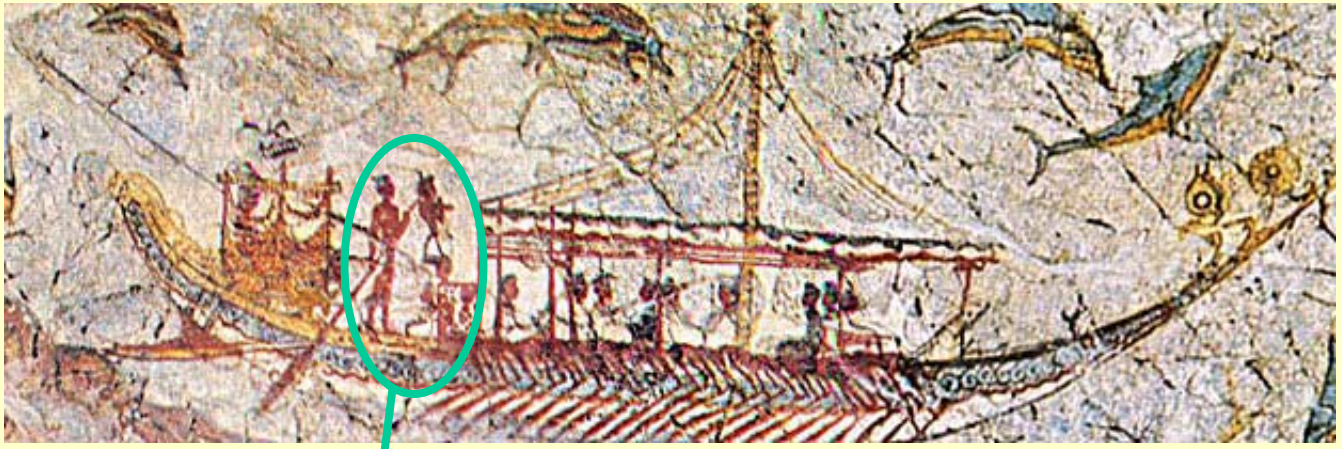
When Mt Diktas visible, steer toward it.

On reaching coast, follow landmarks as shown on main display.

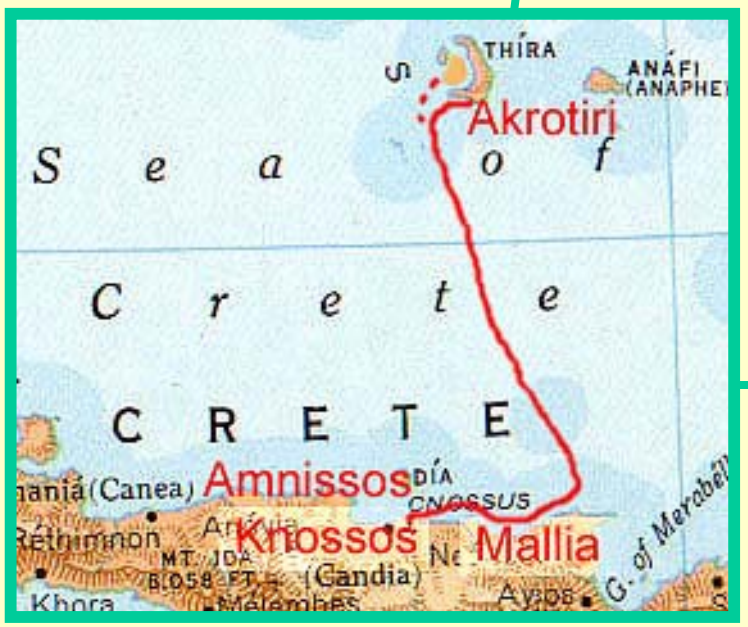
At the time the fresco was painted, there were no reliable clocks to enable accurate navigation out of sight of land. From the heights of Thera, the mountains of Crete can be seen on a clear day, as they can from sea level before a third of the route is completed. It makes sense to row south until you can see Mt. Diktas, then aim for it and go along the coast until you hit Amnissos. Furthermore, paying respects to Mallia would have made sense for a festival fleet.

MTC

Evaluating the imaginary "Fresco" interface



Q2. (Navigator) When the user is the navigator, can he perceive what is necessary?



A2. Yes. He can see that his orders have been entered. By clicking, he can see either or both of the map and the textual instructions.

Depart Akrotiri westward along Thera coast

On meeting fleet, turn south.

When Mt Diktas visible, steer toward it.

On reaching coast, follow landmarks as shown on main display.

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Evaluating the imaginary "Fresco" interface

Q3. Is the user able to influence the element?

A3. (MTO Author) Yes. We have asserted that the Author can emplace ship icons and can enter and modify plans for the Captain, Navigator, and Loadmaster. We have not yet said how this is done, by defining the tools, other than suggesting that there should be a selection mechanism we have labelled "Click". So now we define the requirements (*trivially illustrating the use of the evaluative model for iterative design*).

User input requirements: A means to locate and display a desired segment of the "fresco" picture. This could involve selection of an item from a menu of installed items such as ships and landmarks, or it might involve scrolling the display to a region in which no items have been defined.

Once the desired region of the "fresco" is displayed, the MTO Author needs a method for emplacing entities such as ships, or for influencing the characteristics of the entities already in place. These are equivalent to standard drawing tools in any GUI, though the properties to be affected may involve form-filling, particularly for textual elements.

Evaluating the imaginary “Fresco” interface

Q4. What external influences might affect the user's ability to perceive the element's behaviour?

Examples:

A4.1 The “fresco” interface is physically very long (about 3.6m), and related items may not obviously connect with each other in the MTO Author’s mind (*Implication: ensure that there are engines to test the consistency among formally related items such as navigator’s route map and text, and captain’s timing orders, as well as among the orders for different ships*)

A4.2 Any infelicity in the scrolling and zooming mechanism may affect the Author’s perception of the unity of the entire field. *(Implication: using the same reference model, evaluate carefully the navigation engine).*

A4.3 Poor design of “active icons” such as the ship types or the navigation markers. (*Implication: Evaluate the active icons using the model*).

Evaluating the imaginary “Fresco” interface

Q5. What external influences might affect the user's ability to affect the element's behaviour?

A5. As this is an imaginary interface, this question is hard to answer sensibly. But when evaluating a real interface, the question breaks down into two parts—(1) things that make the actions difficult to perform, such as awkward mapping between devices and actions, or a lack of controlling engines for critical elements, and (2) interactions in which an action to affect one element affects the state of another that the user wants to keep under control.

In this “fresco” interface, one such possibility might be a failure of the developer to build in a consistency check to ensure that the Captain’s mission and the Navigator’s routing did not conflict. Another might be the provision of a fixed entry format for mission details that failed to allow for special circumstances of some particular mission.

Evaluating the imaginary "Fresco" interface

Q6. Is there provision for alerting the user to any other element(s) that might be important at the moment?

A6. Yes, at some points. The yellow and red "X" marks on the various elements of the ships alert the MTO Author to the fact that the content of those items is incomplete or invalid.

In general, the concept of "alerting" applies most particularly in the case of a dynamic dataspace in which the content varies when the user cannot see it changing. Here, it applies because although the user has full control of the content, some details may be forgotten in a complex space. The dynamic and unpredictable nature of human memory has an effect similar to that of an independent data source.

If one considers the operator who is to use the MTO (the Captain, Navigator, or Loadmaster), the interface as so far designed provides no alerting. Alerting indicators should be provided if the MTO calls for anything out of the ordinary, such as an especially fast long rowing period, or (for the Loadmaster) rearrangement of the seats to accommodate special passengers (e.g. an elephant).

A “visualisation system” is a system for presenting, probably interactively, some part of a dataspace, in such a way that a user with some purpose in mind can visualise the import of the data for that purpose.

Important words in this definition (related to the six questions)

presenting : *The system organizes the data for the user’s senses, which need not necessarily be visual (Question 2)*

interactively : *The user can influence what the system presents (Q2 3,4 5)*

some part of *Not all of the data can be presented at once (Q6. Also Implies that there is a Navigation Engine of which the six questions should be asked)*

dataspace : *There is a delimited set of data (No theoretical implication)*

purpose : *The user is trying to perform a task for which the system may provide some assistance (Q1)*

the import of the data : *The user does not want to visualise the data . What the user wants is to see how the data affect the purpose (Q1).*

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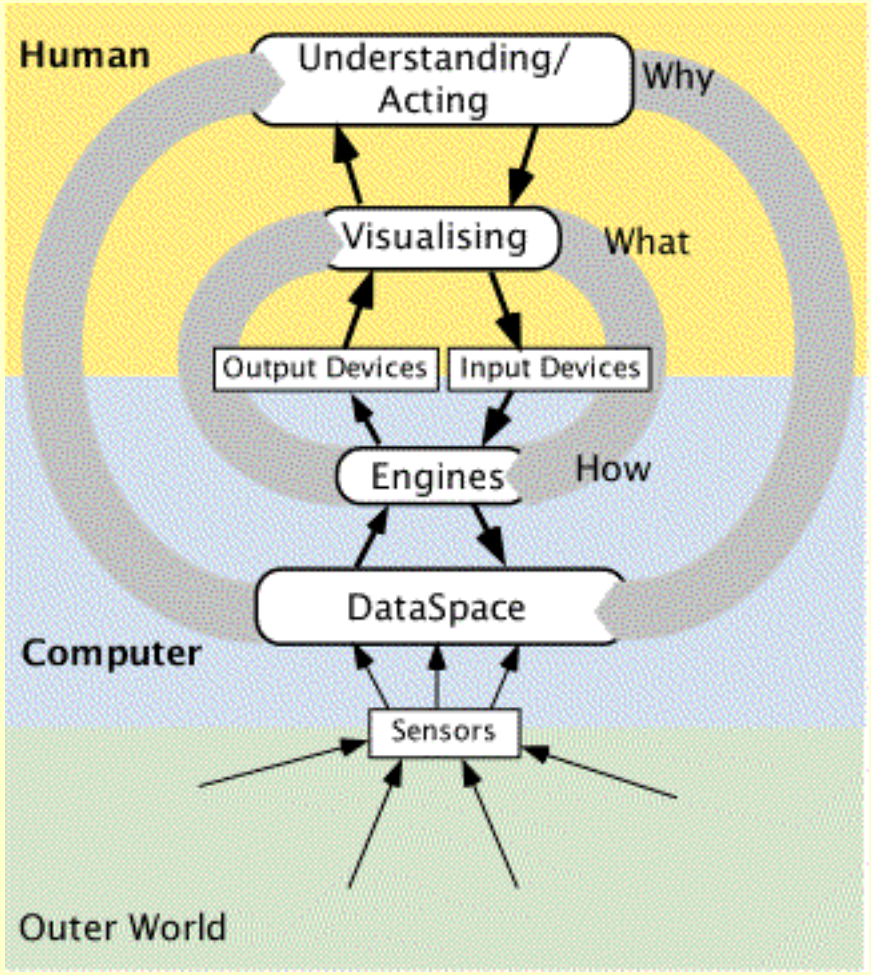
Evaluating the imaginary "Fresco" interface

The middle loop



So far, we have considered only the outer loop in evaluating the "fresco" interface. But we have to consider what "Engines" there might be, and how the middle loop would operate.

Since this is a fantasy visualisation system, an evaluation is difficult to discuss sensibly, but one example may help to illustrate the concept of the nested loops.

Engine-level tasks required for visualisation

For a user (human or silicon) to use the data in a large dataspace for a higher-level purpose, the visualisation system is likely to require at least the following four engine types:

1. Navigation Engine: Navigate to the relevant part of the dataspace
2. Selection Engine 1: Select the relevant data
3. Selection Engine 2: Choose algorithms to apply to the selected data
4. Various Engines: Execute the appropriate algorithms on the selected data

Each engine potentially requires the six questions to be answered in any evaluation of the system. Here, only the Navigation Engine is considered, but it is considered from the viewpoint of two kinds of user.

Navigating in the dataspace (MTO Author)

Q1. Can the user perceive what is necessary?

A1. There are several aspects to the dataspace. Ships and harbours are to be emplaced, and they have attributes that must be specified.

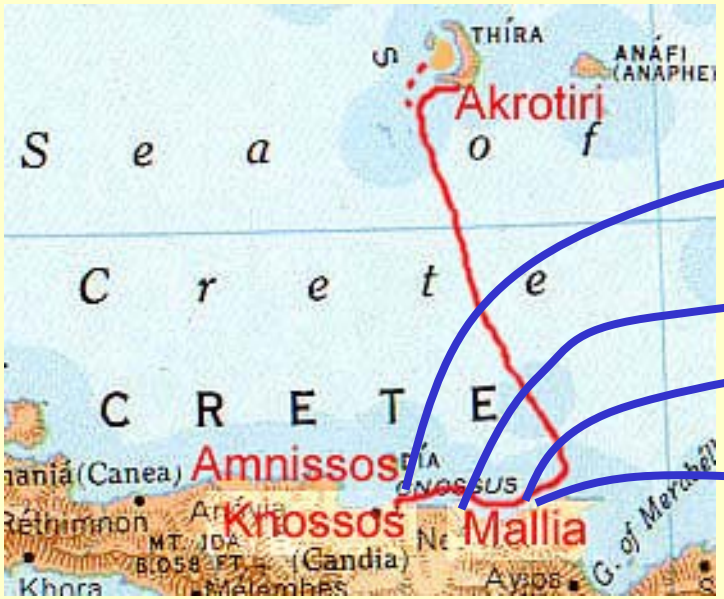
If the screen display shows only undifferentiated sea, within which the MTO Author wishes to emplace a ship, then the answer would be "No." *Implication: The designer therefore needs to ensure that location information (e.g. lat-long, or a small-scale view) is available at least in the open sea areas*.

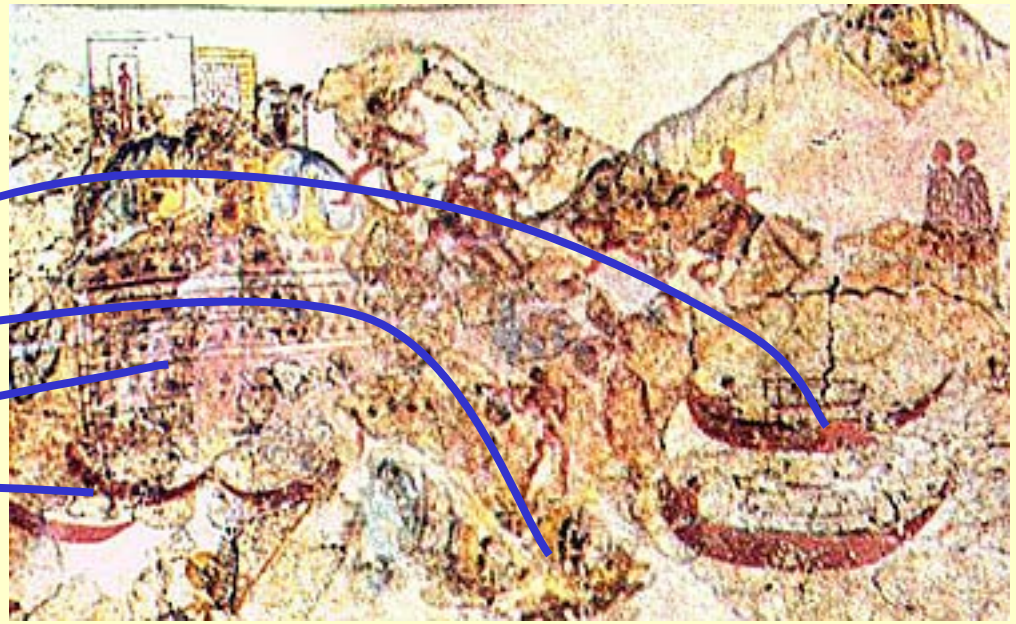
If the MTO Author is concerned with the attributes of a ship, such as the Navigation Plan, and can find the ship on the large display, then the attributes are easily perceived. But this raises the question of whether the MTO Author can identify the desired ship on the large display. *Once more, the evaluation process suggests an iterative redesign, which marks the ship icons with individual identifiers.*

Navigating in the dataspace (Nav Officer)

Q1. Can the user perceive what is necessary?

A1. The Navigation officer needs to perceive both the plan, which is accessible from the icon of his ship, and the import of the displayed landmarks, which are on the main display. The plan should present no problem since it consists of a map and some textual waypoint markers and instructions. To visualise how the landmarks fit into the plan may be less easy.





All of these places are to be bypassed. Can the Nav Officer visualise this?

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Navigating in the dataspace (Nav Officer)

Questions do not have to be asked in the order cited earlier. The question of whether the Nav Officer can visualise the relation between the depiction of an unknown coastline and the map plan is really:

Q4: *What external influences might affect the user's ability to perceive the element's behaviour?*

At this point, the "environment" to be influenced becomes *the set of impediments to the user's ability to perceive*. And the designer would then realize that some means must be provided for relating the components of the plan to the visual landmark display. That could involve a redesign of the display so that the relation is readily visualised by the Nav Officer, or it could involve an engine that, for example, highlights on the map the location of landmarks selected by the Nav Officer (or vice-versa). *Again the evaluation process has suggested the need for a design element not initially included.*

Summary: Using the VisTG Reference Model

Steps:

1. Describe an outer (high-level) loop that relates what the user wants to achieve to his or her ability to perceive the degree to which it has been achieved and his or her ability to act towards achieving it.

2. Examine the degree to which the user can perceive what is necessary.

3. Examine the degree to which the user can choose the necessary actions

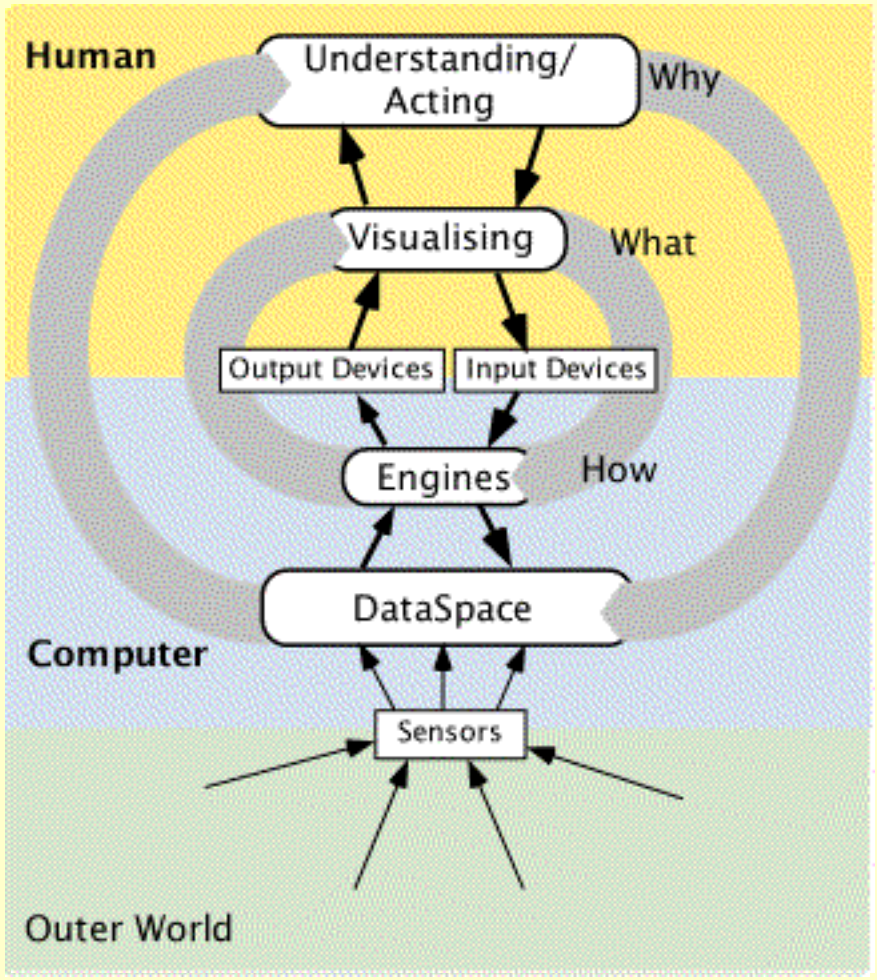
4. Examine any impediments or external influences that affect the user's ability to perceive what is necessary, including implications for training.

5. Examine any impediments or external influences the affect the user's ability to act effectively, including implications for training.

6. Examine the degree to which other parallel events or tasks alert the user that it might be valuable for the user to attend to them instead of this task.

7. Apply steps 1 to 6 to any parallel loops and recursively to lower-level loops whose existence is implied by the results of the earlier analyses.

The VisTG Reference Model again



The VisTG Reference Model has 3 loops, the outer acting through the inner:

(1) The user understanding and acting on the data in the dataspace, which involves...

(2) The user visualising the data provided by and massaged by the engines under the control of the user, using...

(3) The Input-Output devices that interact with the user's sensors and musculature.

But we assume that the user "really" wants to influence the outer world!

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Summary: Using the VisTG Reference Model

The "outer or higher-level loop" with which the seven steps begin can actually be at any level and involve any component of the VisTG Reference Model, from the external-world task through the engines to the I/O devices.

The evaluator can start anywhere, but no matter what the level, always the emphasis is on what the user can be expected to be able to perceive, or, in other words, on "Visualisation".

The VisTG Model for Visualisation

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